

# **A Brief Talk on Anti-icing and De-icing Measures of Road in the Winter**

**Junjun Tang**

**Research Institute of Highway Ministry of Communications  
Key Laboratory of Road Safety Ministry of Communications PRC  
8 Xitucheng Rd, Beijing, China  
mingdujiayuan@yahoo.cn, jj.tang@rioh.cn**

## **ABSTRACT**

Ice-covered roads which often cause traffic accidents and interruption, will result in heavy economic losses, so it is one of main tasks to remove ice in winter maintenance. However, we usually adopt some measures after ice has formed, which will spend a lot of manpower, material and financial resources to remove ice, no matter whether spreading salt and chemicals or using mechanical equipments. This paper discusses if anti-icing that is to take precautionary measures in advance can resolve better the problem of winter maintenance, the essential difference between anti-icing and de-icing measures, as well as their maintenance effects.

## **1. INTRODUCTION**

Road transportation is one of convenient transportation modes, which enjoys a vital position in China's national economy. Because of the impact of rain and snow in winter, the using status of roads is not ideal in many countries, which was manifested as follows: ice-covered roads cause traffic interruption, road conditions are worsen because friction coefficient significantly reduces on ice-covered roads, and the pavements are damaged by low temperature that easily leads to the formation of cracks.

Southern China was hit by exceptionally severe disasters of low temperature, freezing rain and snow at the beginning of 2008. Expressways and main national and provincial highways froze seriously, which caused traffic interruption and passenger transport outage of national main road lines. According to statistics, road traffic of 23 provinces was affected by these disasters. [1] Among of "five vertical and seven horizontal lines" that include 12 state highway main lines and are over 35,000 kilometers, almost 20,000 kilometers of 9 highways had been forced to close. Among of national highways that include 68 highways and are over 133,000 kilometers, almost 40,000 kilometers of 21 highways didn't drive easily because of serious ice-covered roads. In addition, road facilities suffered losses in varying degrees, for example, some roadbed and slope fell in, the roads appeared grooves, and de-icing and spreading salt had effects on bridges and roads. This event exposed that we underestimated the extent of disasters in advance, and anti-icing measures were not sufficient, et al.

Now, how to minimize the ice impact on roads and their users, guarantee clear roads, improve the transportation efficiency, and avoid serious accidents, have aroused so much concern of the whole people. Therefore, this paper analyzes and compares the maintenance effects of anti-icing and de-icing on ice-covered roads.

## **2. CHARACTERISTICS OF ICE SHEET ON ROADS**

After the snowfall, the ice and snow mixture that is formed by people and vehicles rolling, has a hard texture and binds closely with the pavement, so it is difficult to be removed. If snow turns to water because of sunshine or crushing, then the water is converted into ice by freezing, the mixture which contains water, dust and silt will bind firmly with the pavement and be removed more difficultly. [2] Therefore, we must use special de-icing machines to clean up these two states of ice-covered roads.

## **3. ANTI-ICING AND DEICING MEASURES**

China's northeast, northwest, and north lie in the north temperate zone, where the weather is

cold in winter, and the period of snowfall is long for about 4-6 months. When it is raining and snowing, the pavements are easy to freeze, which seriously affects the speed of vehicles, increases energy consumption, causes traffic jams and increases the incidence of accidents. In order to ensure traffic safety in winter and improve transportation efficiency, we must have effective measures to prevent the formation of ice. In general, there are two measures: anti-icing and de-icing.

### **3.1 ANTI-ICING**

Anti-icing means chemicals can be used to prevent the bonding of the snow or ice to the pavement. It is an active and effective measure before predicting ice formation on the pavement.

#### **ANTI-ICING OPERATIONS**

There are three operations for spreading ice control chemicals: using liquid chemicals, using prewetted solid chemicals, and using solids. In the liquid operation, the liquid or solid dissolved in a liquid is sprayed directly onto the pavement. In the prewetted solid operation, the liquid is sprayed onto the solid to form the prewetted mix at the spreader before the combined ingredients are dispersed onto the pavement. In the solid operation, the solid chemicals are dispersed directly onto the pavement.

According to comparison, the prewetted solid operation works more effectively and quickly than two others, which has main advantages as follows: [3]

- The former prewetting operation is preferred to liquid applications because it is cleaner and works better. The agents do not cake in the spreader and corrode it as much;
- Chemicals only have a de-icing function after they are dissolved. Solid chemicals which are dispersed onto the pavement need to be rolled several times by passing vehicles before melting, so the effect of de-icing has been reduced. Particularly in some roads with little traffic, solid chemicals melt more slowly, thus they may lose the de-icing function;
- Solid chemicals need to absorb heat from the outside in the process of dissolving. When they are dispersed onto the pavement, they will absorb a lot of heat from the pavement which can lead to a sharp drop in pavement temperature, then the pavement happens to crack and its life is affected. Prewetted solid chemicals are melted in the spreader before they are dispersed onto the pavement, so they will absorb the heat from the equipment and atmosphere, which may reduce the damage to the pavement;
- Solid chemicals dispersed onto the pavement are easily taken away by passing vehicles and the wind, which will cause that both sides of the road accumulate lots of chemicals, but the pavement is lack of necessary chemicals;
- Foreign studies show, under the same conditions of spreading functions, we compare the prewetted spreading equipment with the unpwetted in order to achieve the same de-icing and anti-skid effects. The former can save fifty percent of the chemicals use, which is extremely important to reduce the total costs of de-icing operations and meet environmental protection requirements.

#### **ANTI-ICING METHODS**

Application of the anti-icing chemicals should be prior to precipitation beginning to fall, but when to begin anti-icing operations depends on an array of data from different sources, including the Road Weather Information System (RWIS) and national and local weather forecasts. In addition to reporting dew point, humidity, air temperature, and wind velocity and direction, RWIS also reports road conditions via pavement sensors that monitor pavement temperatures and the amount of anti-icing chemicals present on the pavement. Once all of the data are fed into a central database, various modeling techniques can be used to accurately predict the start of ice formation on the pavement and the times to start the anti-icing applications.

Usually, anti-icing chemicals must be applied to roads one to two hours before the precipitation begins, and they are spread about 5-10 grams on per square meters pavement, which can effectively prevent ice formation on the pavement. [3] But this is not absolute, we need to consider the types, freezing point and concentration of chemicals, and temperature, weather forecasts, probable precipitation and traffic, then spread the chemicals many times by group until they achieve the setting quantity in advance. However, many maintenance personnel desperately increase the spreading

quantity of chemicals, which not only consumes the use of chemicals, but also seriously damages roads, the environment and plants.

Ascertaining the time and quantity to reapply the chemicals are accomplished with the observation of pavement friction to automobiles. These friction measurements can be determined by an available friction instrument installed in a vehicle connected to its speedometer system. Maintenance personnel drive the vehicle on roads and measure the friction of the road by applying the brakes for a few seconds. Thus, they can determine in this way whether more chemicals need to be applied and when.

## **3.2 DE-ICING**

### **DE-ICING OPERATIONS**

Now, mechanical and chemical de-icing are mainly adopted and more effective ways at home and abroad. Mechanical de-icing has some advantages of flexibility, rapid speed, wide application and no temperature restriction, but there are also some shortcomings of poor cleaning effect and damaging the pavement. [4] Chemical de-icing is similar with the former anti-ice operation. It is an effective means of de-icing that can compensate for the absence of mechanical de-icing, but it has a great impact on the surrounding environment, especially for reinforced concrete and bridges. Compared with chemical de-icing, the biggest advantage of mechanical de-icing is environmental protection. However, when the thickness of snowfall is over two centimeters, we must first use mechanical de-icing to thin the snow or ice layers down, then begin chemical de-icing. And as long as it has been snowing, it is necessary to use two ways to work alternately. [3] Another operation is manpower de-icing, which has characteristics of low efficiency and high labor intensity, so it is less to be used.

Using mechanical de-icing needs to pay attention to:

- To ensure that de-icing equipments have a certain amount of pressure in order to effectively remove the bonding of the snow or ice to the pavement;
- In the process of de-icing, de-icing equipments need to be reasonably equipped which can ensure all equipments well cooperated, and prevent the friction damage to the pavement. And de-icing equipments should achieve low-loss de-icing, the hardness of whose material must be less than the pavement's;
- When using mechanical de-icing, we must take tight security measures, such as setting up the warning lights on expressways, in order to avoid accidents. [5]

### **DE-ICING EQUIPMENTS**

The formation characteristics and physical properties of ice sheet on roads largely determine the method of de-icing operations, so different de-icing equipments are accordingly adopted. It is important to control chemicals, but using correctly de-icing and spreading equipments can achieve the effects of rapid de-icing and reduce environmental pollution.

- De-icing equipments. De-icing equipments can be divided into self-walking and towed-walking by walking ways and cutting means include attacking, cutting and breaking. [6] De-icing equipments should have security system, where revolving and cutting elements can avoid fully the obstacles, and the distance and direction of throwing ice devices should be adjustable to accommodate different road width and intersections. In addition, de-icing equipments should have a higher productivity, lower costs and expenses;
- Spreading equipments. The high-precision spreading equipments must be used in order to ensure the chemicals spread accurately. Developed countries prohibit to use artificial means and low-precision equipments to remove ice. The precision degree of spreading equipments needs to be calibrated by specialized agencies in order to determine whether the equipments can be used. Once the calibration haven't been passed, the equipments will be prohibited de-icing operations.

## **4. COMPARISON OF ANTI-ICING AND DE-ICING**

Results of the foreign testing have shown that chemicals can be used much more effectively to prevent the bonding of the snow or ice to the pavement (anti-icing) than to destroy the bond once

formed (deicing). [7] For winter road maintenance, we should use preventive anti-icing measures as far as possible to replace traditional de-icing measures. Anti-icing has some advantages as opposed to de-icing.

- Anti-icing required less chemicals to be used for the same level of maintenance than de-icing procedures;
- The same amount of chemicals used produce an increased level of maintenance as compared with de-icing operations, so anti-icing is more effective and economical;
- Anti-icing also reduces the need for abrasives. Because anti-icing chemicals do not allow ice to bond with the pavement, abrasives are not needed. As a result, cleanup costs are significantly lower.

## 5. CONCLUSIONS AND PROSPECTS

Although anti-icing and de-icing operations have advantages and disadvantages, anti-icing operations have very good development prospects and direction, and also have huge obstacles. Of course, before the preventive anti-icing measures haven't been taken timely, the traditional de-icing measures are still in use. Domestically, various de-icing agents and new types of snow and ice plough vehicle are increasingly apparent. We believe that with deep studies, more effective and energy-saving anti-icing technology and devices can be developed. At the same time, we may also take some measures to reduce that anti-icing and de-icing have the damage on roads and environment.

- However, using chemicals, which is an effective means of winter road maintenance, couldn't be refused soon only according to chemicals' effect to environment. In the use of chemicals, their de-icing effect, de-icing time, corrosiveness, harmfulness, and other factors must be learned clearly. And in accordance with precipitation, temperature and other conditions, the using states and corresponding concentration of chemicals must be determined, the spreading quantity of chemicals must be reasonably controlled, and the time of spreading chemicals must be confirmed;
- New types of environment-friendly chemicals need to be developed. They will have good anti-icing and de-icing effects, have characteristics of the weak corrosiveness and preventing rust, and reduce the damage to metal pipes, pavements and environment;
- On the premise of not ensuring that chemical de-icing has no harm to roads and environment, mechanical de-icing is used as far as possible;
- It is necessary to take comprehensive control measures to enhance the ordinary durability of new roads, such as mixing air-entraining agent, mixture and aggregate, controlling water-cement ratio, using steam curing to precast concrete, and paying attention to construction conditions; [8]
- Segregating layer is designed during the construction of roads and bridges in order to prevent the harmful chemicals from entering into them. At the same time, drainage system on the pavement needs to be designed reasonably so that chemicals can flow away easily. All these may decrease pavements maintenance costs which are produced by winter anti-icing and de-icing operations;
- Salt-tolerant plants may be chosen to be planted at roadsides and medians where are easy to gather chemicals, and using shelter may also protect plants from chemicals.

## REFERENCES

1. Work summary assessment report of National transport system to oppugn low temperature, freezing rain, and snow disasters. 2008
2. Zhongyue Huang. et al. Research on thermal and machine method of snow removing. pp 28-30. RM & CM. 2004
3. Haibin Fan. Application of overseas snow melting materials. pp 5-7. RM & CM. 2006
4. Jie Fan. et al. Application of snowmelt agents to pavement snow-removing and the prevention of its disservice on environment. Vol 26. pp 78-81. Journal of Chongqing JiaoTong University. 2007
5. Peng Nie. Study of improving anti-salt denudation for pavement concrete by adding K-TYPE additive. Vol 22. pp 25-27. Northeastern Highway. 1999

6. Runli Zhang. et al. Modern de-icing technology. pp 60-62. Transpoworld. 2004
7. Brian Chollar. A Revolution in Winter Maintenance: <http://www.tfhrc.gov/pubrds/winter96/p96w2.htm>
8. Yanqiu Xiao. et al. Deterioration analysis and prevention of the de-icing salt on cement concrete pavement. Vol. 149. pp 33-35. Communications Science and Technology Heilongjiang. 2006